

Experiences in Deployment of a Web-based CIS for Referring Physicians

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Improving the timeliness and efficiency of information exchange between the hospital and clinicians in the health care community is an area of active interest at the Massachusetts General Hospital (MGH). Providing computer-based access to referring physicians who are not formally affiliated with the hospital is a particular challenge, since these offices are not connected to the hospital network and lack the standard hospital workstation hardware and software. Installing clients for the hospital's clinical applications at these sites has been a difficult and costly proposition. The emergence of Web technology yields an alternative method for developing clinical applications for this remote, diverse user population. We present our experiences during the first six months of deployment of a Web-based clinical information system designed for use by referring physicians.

INTRODUCTION

We have implemented and deployed a Web-based clinical information system (CIS) that allows referring physicians at remote offices to access the hospital's clinical information repository. The suitability of Web technology for prototyping and implementing clinical information systems has been well documented.¹⁻⁴ Results collected during the first six months of deployment of our application support the viability of a Web-based application as an alternative to the standard workstation client for remote clinical data access. The application architecture has been stable, inexpensive to maintain and easy to upgrade. User training and support requirements have been acceptable. Referring physicians have indicated a high level of interest in the application and installation rates have been high.

Actual usage statistics during this initial period, while low, are consistent with the application's role as an accessory method of data retrieval for a limited patient population. Information gathered during installation and support has been helpful in clarifying clinical usage patterns and user behavior. Future assessment of the costs and benefits of this approach will be guided by findings from our experience to date.

BACKGROUND

The Referring Physician Information Access (RPIA) project's Clinical Summary, developed at the Laboratory of Computer Science (LCS) has been described previously.⁵ It allows referring physicians outside the hospital to retrieve clinical information about their patients from the hospital's clinical data repository. Discharge summaries, operative notes, and diagnostic reports from radiology, cardiology, pathology and microbiology are offered going back over a two year period; the most recent chemistry, hematology and immunology results are available in summary format.

Through this application, referring physicians have an alternative method to access information on patients they have referred to MGH. Access to information is read-only. Users must dial into a secure modem pool, and provide a valid hospital network username and password. The user then selects from a list of his or her own patients. A list of available reports for the selected patient is displayed, from which the user can choose. The interface is designed to minimize the number of transactions between the client and Web server, and to provide the most direct possible user interaction.

Application Design

The application is based on Web technology and middle layer services written for the hospital's electronic medical records system. Web technology provides the application's user interface and data transmission protocol. Users dial into the hospital network via modem. Once connected, they request and view information through a standard Netscape browser. Queries from the client browser are processed using CGI scripts on the Web server. Query results are rendered in HTML and returned for display on the client browser. Data transmitted between the client browser and the Web server is encrypted using the Secure Sockets Layer (SSL) supported by Netscape products.⁶

The application's database interface is provided by services originally written for the hospital's electronic medical record system (EMR).⁷ These

EMR "middle layer" services provide access to the clinical data repository and perform user authentication and authorization. Reuse of existing services greatly reduced costs during the design and implementation. Additionally, since the data views presented by the application are inherited from the EMR, the application has been more readily accepted by test users and data administrators alike.

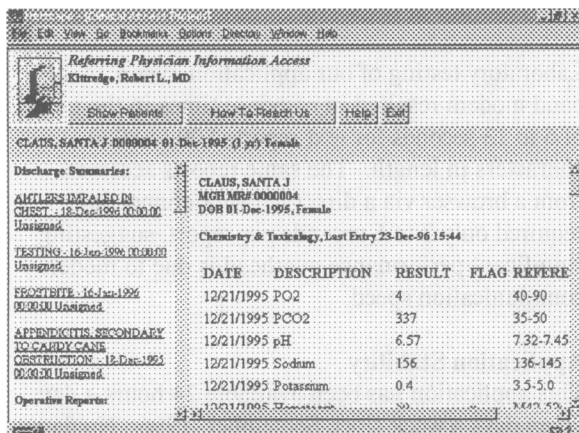


Figure 1: Screen capture showing a sample report page. The provider has selected a patient and a report to view (from the report titles list on the left side of this screen).

Prior to retrieving patient information, users are required to authenticate using a hospital network domain username and password. The username and password are verified against the hospital's NT security server using services developed for the EMR. Every subsequent user query is accompanied by a security token which is validated on the security server by the EMR middle layer services handling the request. All transactions on the Web server and application server are recorded for auditing purposes.

Patient-Physician Linkage

Signed patient consent is required prior to allowing a referring physician access to a patient's hospital record. The patient consent form identifies the referring physician and authorizes release of information. Signed consent is most readily obtained from inpatients passing through the admitting office. Admission reports are reviewed daily to identify patients who have signed the written consent form identifying a referring or primary physician to whom patient data is to be released. This information is then recorded through an administrative application, adding the patient to the

referring physician's patient list and giving the physician access to that patient's record via RPIA.

METHODS

Information concerning deployment to date and early usage of the application at referring physician offices has been collected. Data from installations has been collected from the support staff records. User support data is derived from support staff records and LCS staff. Application activity and performance statistics are available from the application and server logs.

Deployment

Several roles have been identified during the deployment of RPIA. An MGH physician promoter and liaison works to actively identify and recruit referring physicians into the user pool. This individual has been involved with the project from its inception. A remote technical support specialist serves as the primary contact for the referring physician's office and performs demonstrations, installations, and user training. LCS staff maintain the application and provide backup support.

The application is presented to our referring physician community primarily through direct contact with the physician promoter from MGH. This individual contacts and meets with referring physicians, and shows a demonstration version of the application to interested physicians. He also initiates paperwork to obtain hospital security accounts for the referring physician, and does limited evaluation of the site's readiness for installation. Alternatively, the support staff may initiate contact with an identified office. Once a potential installation site is identified, the support staff schedules a visit. The initial site visit includes evaluation of hardware and software and demonstration of the application.

To date, referring physicians who are candidates for RPIA have been identified primarily through one of two methods. The earliest installation sites were referring physicians identified by the physician promoter, who drew on first-hand knowledge and contacts to select sites. More recently, installation sites have been identified through review of monthly inpatient admission records to identify referring physicians with multiple recent admissions. The rationale for this selection method lies in the assumption that referring physicians with a recent history of patient referrals to MGH are more likely to find the application valuable.

Installation of the Netscape browser and dialer software, testing and user training may occur at the initial site visit or is scheduled for a follow-up visit. Minimum site requirements for an installation are a Windows OS, 8Mb of RAM, and a 14.4 Kbs modem connected to a phone line. The Netscape browser is installed from diskette or CD, and the browser's user preferences and dial-in properties are set. A trial login confirms a successful installation prior to the training session with the user. A pager carried by a member of the support team allows users 24 hour access to technical support.

FINDINGS

Deployment of the application at referring physicians' offices began in September, 1996. As of mid-March, 1997, the Netscape client had been successfully installed on 19 computers at 14 different practice locations, serving a total of 41 referring physicians. Practice locations range from the immediate Boston area to sites as distant as West Palm Beach, Florida.

Practitioner Site Installation

Time required for site visits to install the Netscape browser varies, but generally is about 30 minutes, with an additional 10 minutes needed for testing. Once the application is successfully installed, the physician and/or office staff is introduced to the application. Again, the time required varies, but typically is less than 30 minutes. Installation at a single-physician site usually requires about one hour.

There have been three unsuccessful Netscape browser installations. Two of these were due to insufficient hardware, and one due to a software conflict. The overall site installation success rate is 86% to date.

Usage and Performance

Usage has been recorded over a six month period to date, from September through March. During this time period, a total of 22 user sessions were recorded. For the purpose of usage analysis, a user session has been defined as a user login initiated outside the context of installation or support activity, with at least one patient report retrieved prior to logout. Sessions were recorded for 10 different users, with 6 users recording more than one session. For users with more than one session recorded, the mean time elapsed between sessions was 25 days, with a range of 0 to 91 days. Most sessions consisted

of a login followed by a patient selection and a single report retrieval; the average number of reports requested per session was 1.3.

Performance for Web-based applications must be measured at the browser, because the transmission of data between the client browser and the Web server accounts for a significant fraction of response time. All usage information for our application to date has been recorded at the server.

Laboratory testing of our application over a 14.4 k baud modem resulted in response times in the range of 6 to 13 seconds for text reports 800 to 8000 characters in length. The same reports accessed from a browser via a direct network connection required only 2 to 6 seconds per report, suggesting significant performance overhead is due to modem communication speed.

Application Stability

This application has been available 24 hours a day, seven days a week since September, 1996. No down time has been attributed to the Web server or dial-in modem pool. There has been roughly one system down event recorded per month over the last three months, caused by problems in the EMR application environment and the connection to the clinical data repository. A monitoring program has been installed to alert support staff if the application becomes unavailable.

Costs of Support and Maintenance

The hardware and software resources required for initial development and implementation of the application have been described previously. Hardware and software costs generated during the deployment phase to have been limited to purchase of browser software and increasing dial-in capacity of the modem pool.

The application is maintained and supported by one project manager and one programmer analyst, together accounting for 1.5 full-time equivalents (FTE). Staff for client installation and remote user support adds one full additional FTE. No accurate cost information is available for tasks generated by the application but performed by non-project staff, such as new user account setup, patient-physician linkage administration, and project hardware and software support tasks borne by network management.

The support staff has logged a total of 44 site visits, making an average of 2.3 site visits per successful installation. Nine requests for user support have been recorded.

DISCUSSION

Our experiences during the first six months of deployment of a Web-based clinical information system for referring physicians support the viability of this approach to clinical data access in this setting.

The expected benefits of using a multiplatform, off-the-shelf, "thin" client (the Netscape browser) are supported by the high ratio of successful to attempted site installations. The Web server software has proven stable and easy to manage. Since no client modification is required, upgrades and modifications to the application have been made at low cost and with no inconvenience to users.

Users appear to readily accept the application's Web interface. The importance of an intuitive, familiar user interface is heightened here, since most referring physicians will need to access this application on an infrequent basis. (Most information continues to be conveyed by faxed or mailed reports). The large mean time between accesses observed (25 days) suggests that users are indeed comfortable returning to the application after long intervals.

The mode of use by referring physicians may differ significantly from that envisioned during application design. Though anecdotal, feedback to our support staff indicates that referring physicians may primarily rely on paper copies of reports printed from the browser, rather than viewing the results directly on the screen. Moreover, there was significant interest in providing training to office support staff; in many cases, referring physicians might not use the application directly, but rely on office staff to retrieve and print reports. This is consistent with general procedures for report retrieval in most offices, and with the fact that most of the browser installations to date are on computers located in staff areas rather than exam rooms or physician offices. Behavioral information of this kind is important, since drill downs to additional data and hyperlinks to knowledge sources are ineffective if the clinician is not directly interacting with the application.

Prospective protection of patient record access through mandatory patient-physician linkage is desirable as a means of limiting the potential for large-scale breach of patient confidentiality through this type of application. The model for patient-physician linkage, however, has been problematic. In order to be of value to referring physicians, the application must consistently provide patient information to appropriate users. Signed patient consent, however, is not consistently obtained during inpatient admissions, and is rarely obtained during outpatient visits. In some instances, this has become an obstacle to use of the application. One internal spot analysis of patient consent figures revealed that only 68% of inpatients had signed consent forms at the time of discharge. Efforts to improve the capture of patient consent are underway, and will likely succeed. However, as has been noted previously, the rapidity with which care-giver roles change in the current health care environment makes it costly, if not impossible, to keep pace with this information.⁸

Other problems with obtaining signed consent for release of patient information have become apparent. The current model of patient consent as implemented in our application does not support "cross coverage." Information retrieval for "cross-covering" physicians has been frequently requested among group practitioners who need access to information on patients for whom they have not been identified as a primary care provider.

As these issues are clarified and solutions are implemented, new versions of the application will be released. As the number of installed sites rises, the cost-effectiveness of the thin client may be magnified. Since the EMR services that handle queries and the CGI's that generate the Web pages are maintained on the server, these can be modified locally. The client browser does not need to be upgraded with each new release of the application, eliminating a cause of repeat site visits.

CONCLUSIONS

Our experience during the deployment of RPIA to referring physicians' offices over the past six months suggests that Web-based CIS's provide a realistic means of distributing clinical information from the hospital clinical data repository to referring physicians practicing outside the hospital network. Referring physicians have demonstrated enthusiasm and acceptance of this application. The application itself has proven robust and capable of performing in

the clinical environment. Support and maintenance requirements to date have reasonable.

Web technology provides benefits following deployment as well as during implementation. The familiar user interface appears to provide no barrier to use, even for infrequent users. The ease with which encryption can be incorporated significantly enhances security. As Web technology continues to mature, the benefits of Web-based application development can be expected to grow.

Formal assessment of the costs and benefits of this application, like most others, is difficult to perform. The variety of hidden costs, together with the difficulty of defining and measuring immediate benefit are challenging obstacles. None the less, the need for formal evaluation is likely to intensify in the future health care environment

Usage statistics and installation data suggest that the application may be utilized in a manner different from that envisioned during development. Referring physicians may review information in printed form rather than viewing it directly on the browser. Methods of incorporating links to additional patient data or knowledge sources will need to be reevaluated, and usage behaviors need continued monitoring. As the application matures, the release of new versions will underscore the importance of a thin client that does not require modification.

These preliminary data can serve to guide future application development, as well as efforts to assess the costs and benefits of implementing, deploying and maintaining a Web-based hospital CIS for referring physicians.

Acknowledgments

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